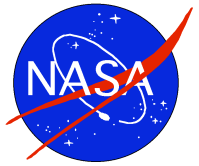
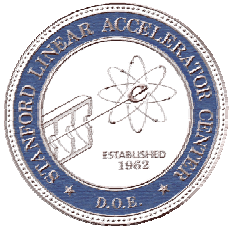


Section 5.5

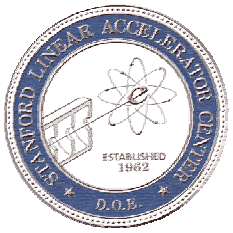
LIOC - SAS



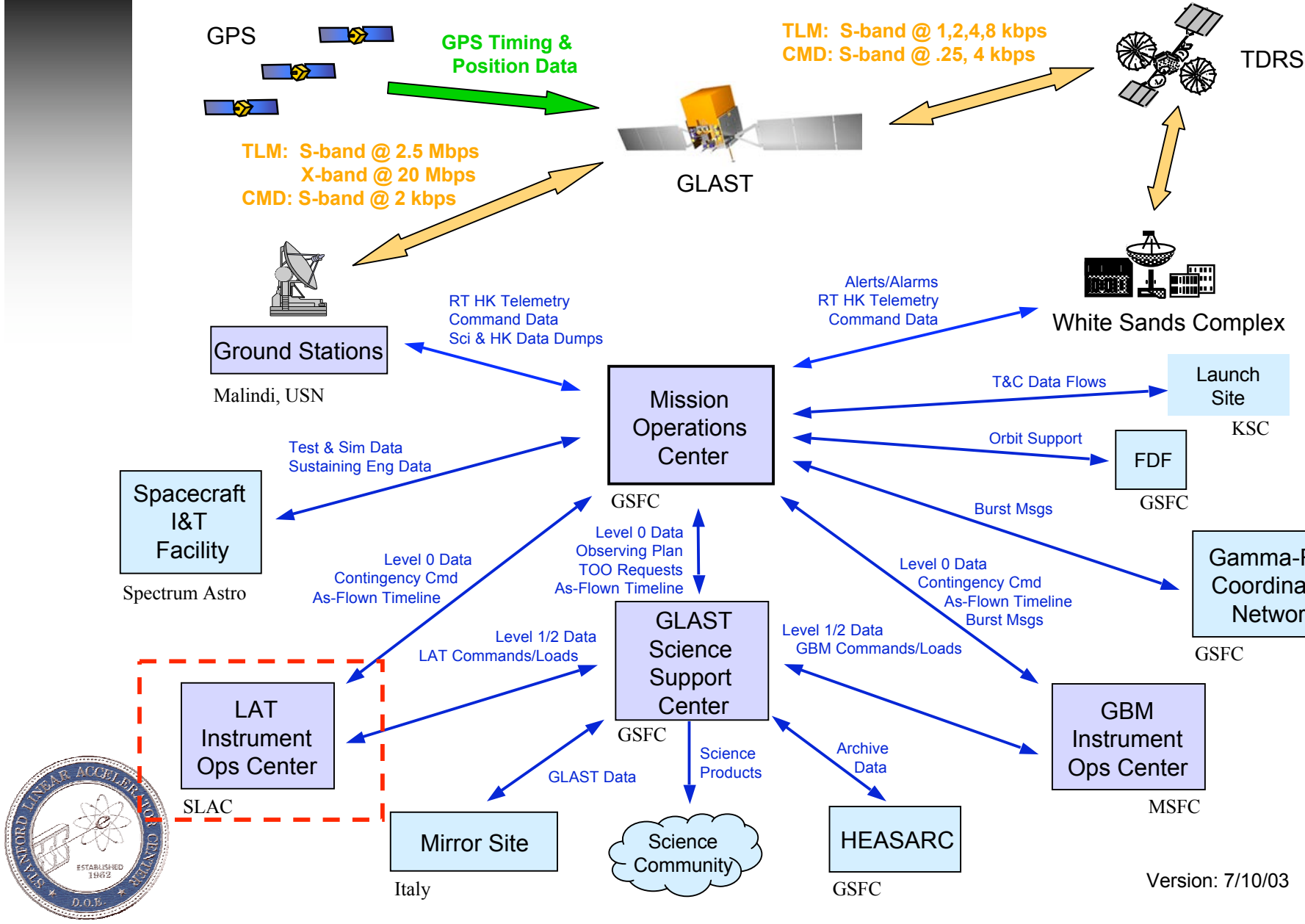
Richard Dubois
SLAC

Outline

- ***Introduction to SAS***
- ***SAS Mission as defined by Level 3 Requirements and Milestones***
- ***Instrument Simulation and Event Reconstruction***
- ***Support of LAT Instrument Engineering Tests***
- ***Software Development Approach***
- ***Level 1 Pipeline progress***
- ***High Level Science Tools development progress***
- ***Mission Ground Systems End-to-end testing***
- ***Preparation for LAT Ground System Peer Review and CDR***
- ***Summary***



Ground System Architecture

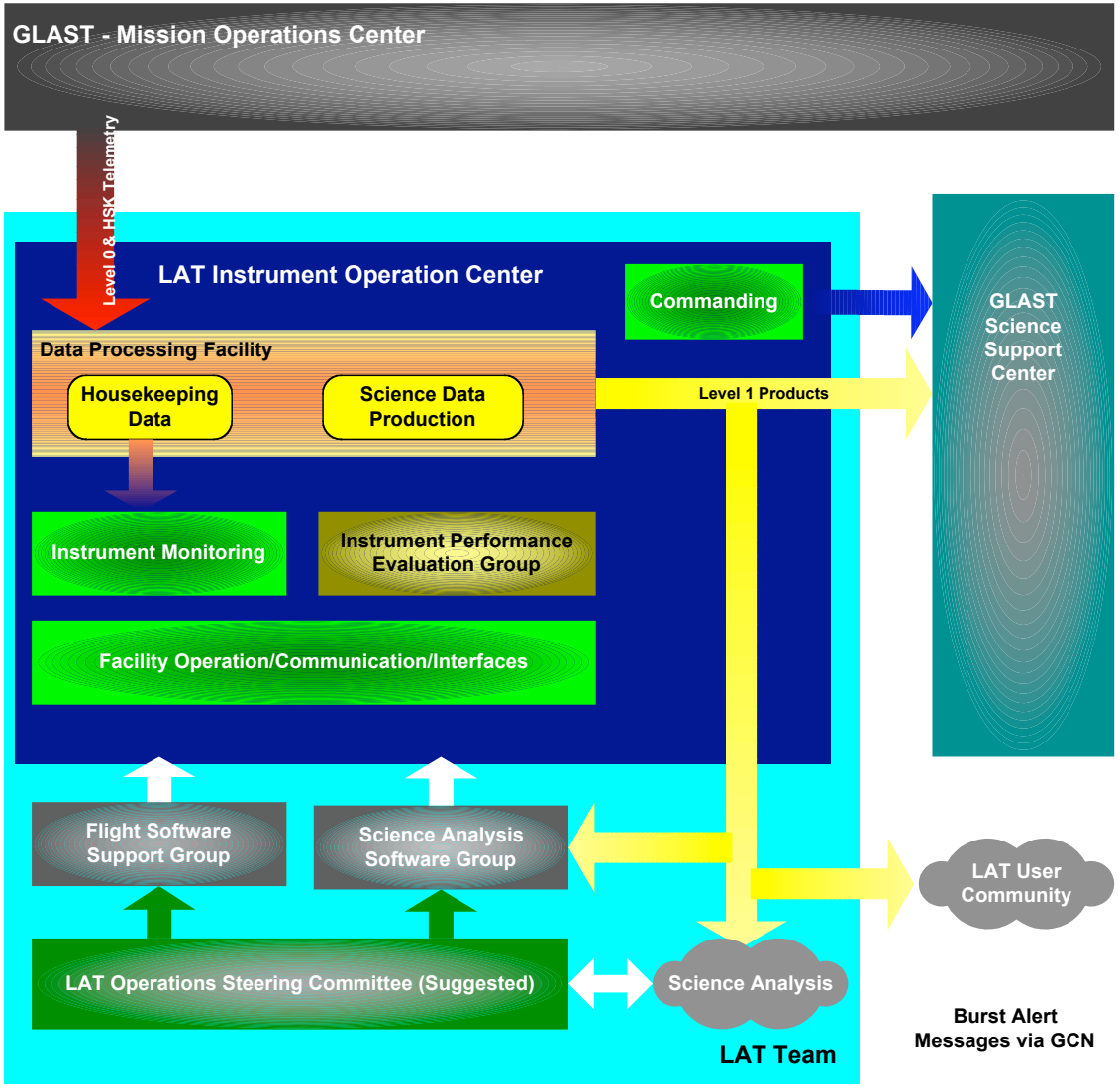


Version: 7/10/03

SAS in the Ground System

DPF is robotic backbone of IOC/SAS process handling –
Performs L1 & L2 processing

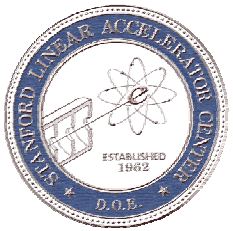
DPF server and database can handle
multiple arbitrary sequences of tasks:
L1 pipeline; reprocessing; MC; ….



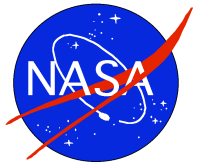
Keep everything on disk

SAS Key Requirements

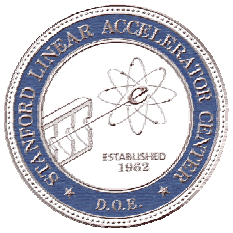
- ***Data Pipeline***
  - *Perform processing of Level 0 data through to Level 1 event quantities*
  - *Generate Level 1 products within 24 hours of receiving the corresponding Level 0 files from the MOC*
  - *Provide near real time monitoring information to the IOC*
  - *Monitor and update instrument calibrations*
  - *Reprocess instrument data*
- ***Perform bulk production of Monte Carlo simulations***
- ***Higher Level Analysis***
  - *Create high level science products from Level 1 for the PI team*
    - *Transient sources*
    - *Point source catalogue*
  - *Provide access to event and photon data for higher level data analysis*



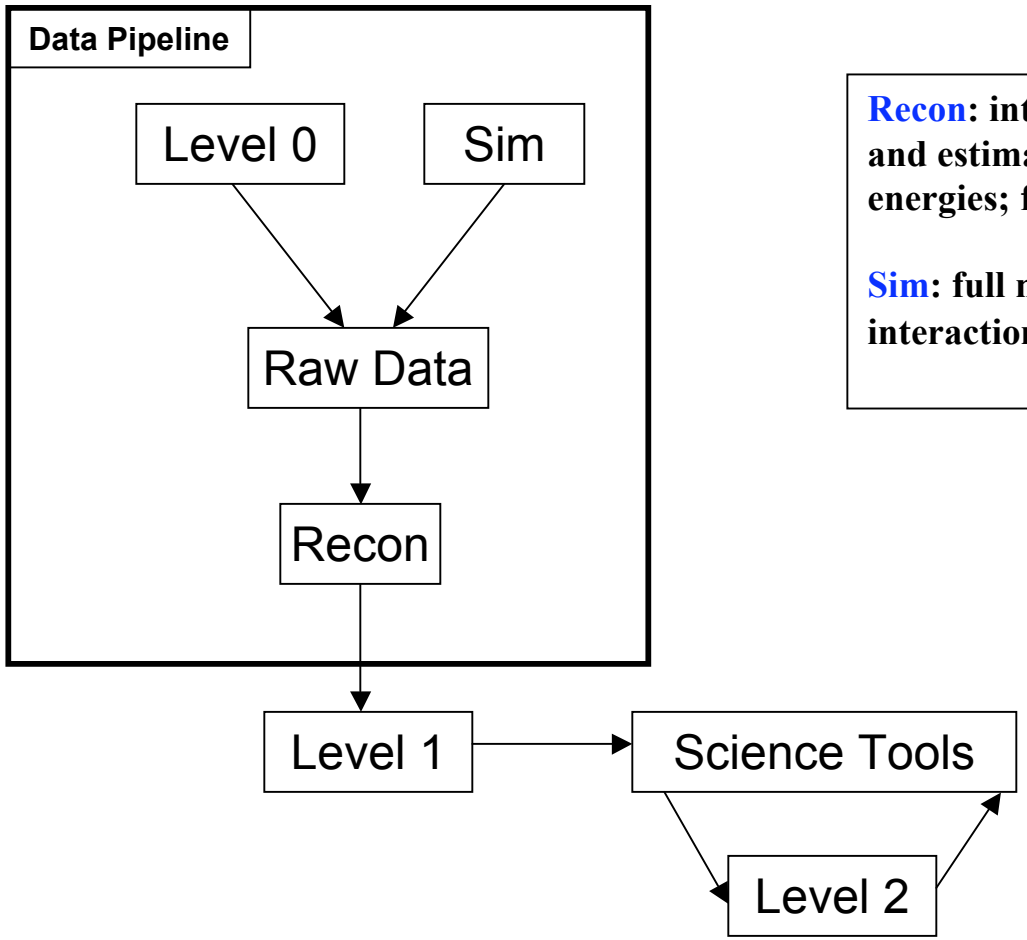
SAS Key Requirements



- ***Provide capability to produce, update, and make public the models used for the analysis resulting in the LAT source catalogs***
- ***Interface with other sites (sharing data and analysis tool development)***
  - *Mirror PI team site(s)*
  - *GSSC*
- ***Support Engineering Model and Calibration tests***
- ***Support the collaboration for the use of the tools***
- ***Archive Level 0 data for the life of the mission***
- ***Provide all archived data products to authorized users for the life of the mission***



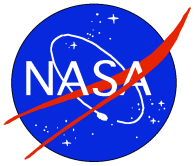
Processing Flow



Recon: interpret LAT readout and estimate directions and energies; flag background

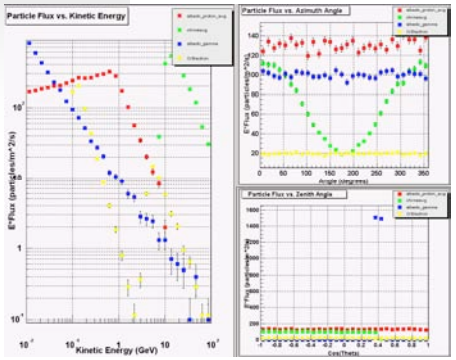
Sim: full modeling of e/□/p interactions and readout in the LAT

Level 1 Sim/Recon Chain

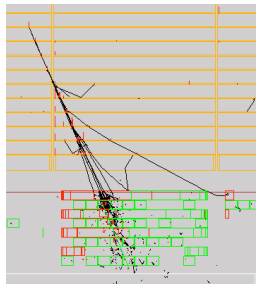


3 GeV □

Source Fluxes

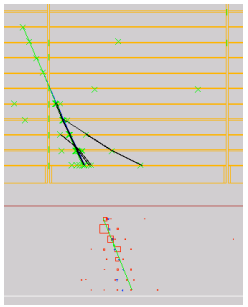


Particle Transport



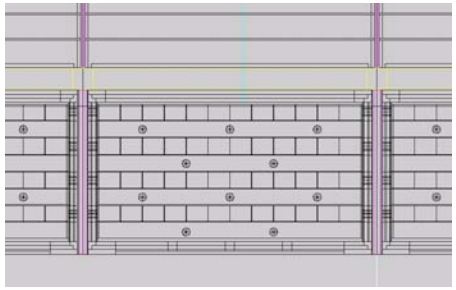
"Raw" Data

Real Data



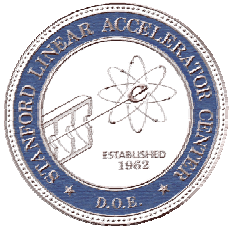
Recon

Geometry

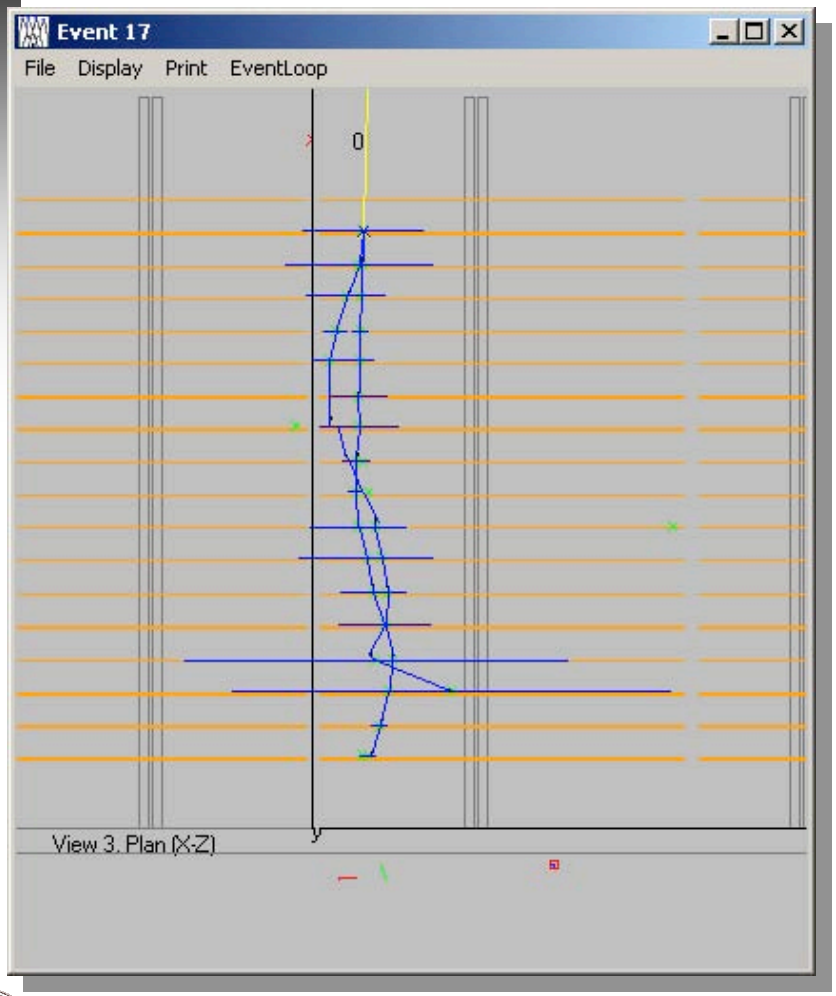


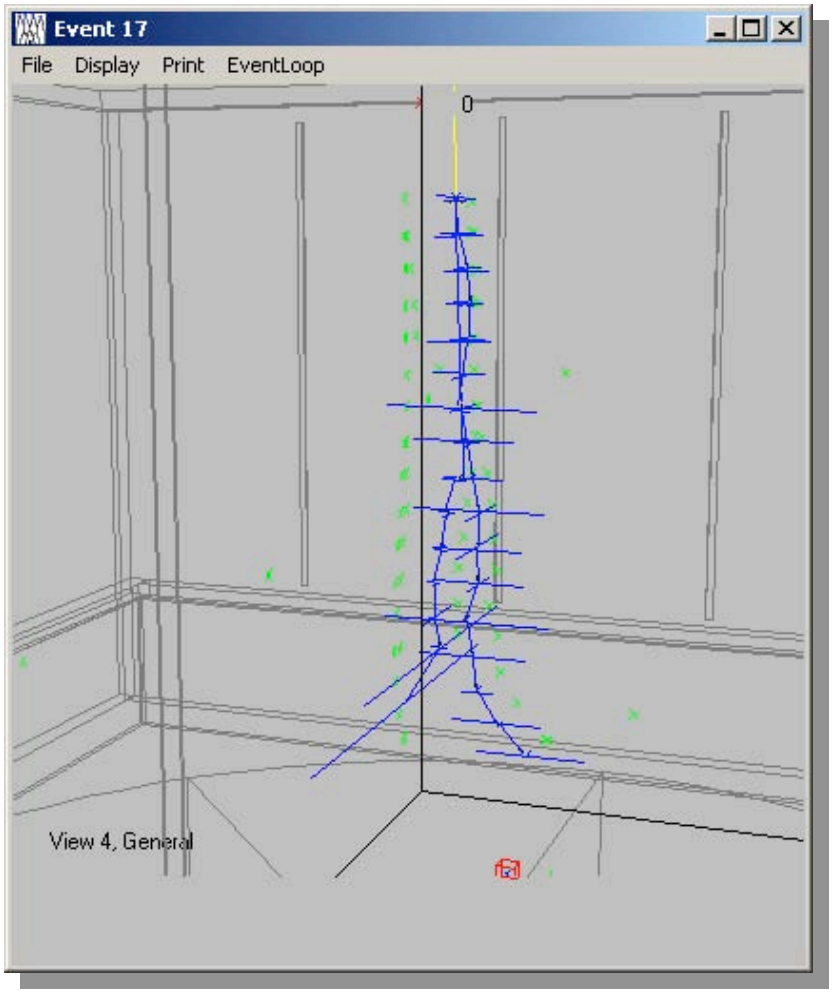
Background Rejection - Particle ID

Level 1



Tracking Reconstruction Example



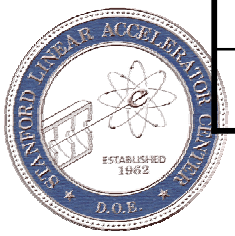


100 MeV Gamma

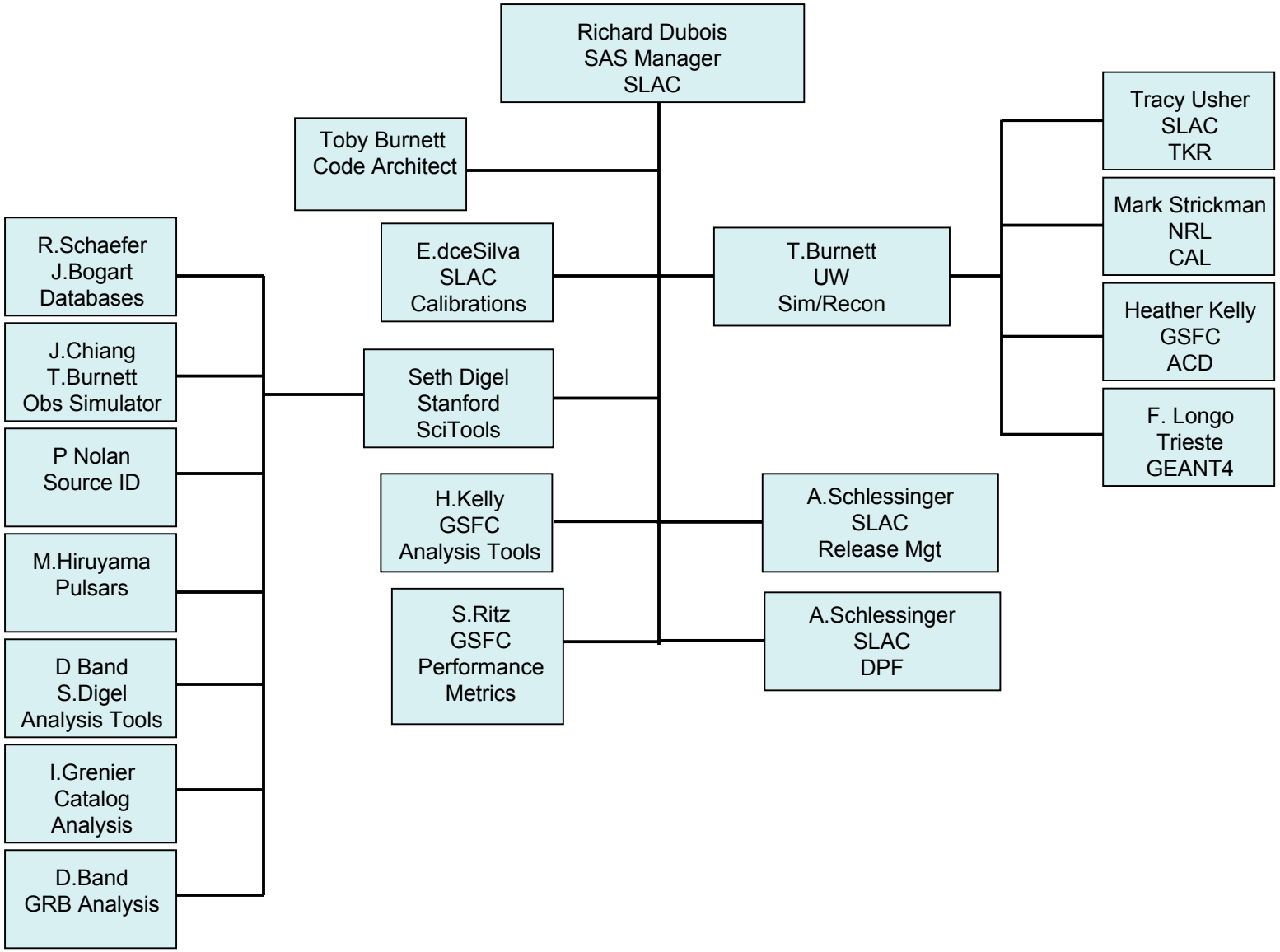
T.Usher

Sim/Recon Toolkit

Package	Description	Provider	Status
ACD, CAL, TKR Recon	Data reconstruction	LAT	90% done In use
ACD, CAL, TKR Sim	Instrument sim	LAT	95% done In use
GEANT4	Particle transport sim	G4 worldwide collaboration	In use
xml	Parameters	World standard	In use
Root	C++ object I/O	HEP standard	In use
Gaudi	Code skeleton	CERN standard	In use
doxygen	Code doc tool	World standard	In use
Visual C++/gnu	Development envs	World standards	In use
CMT	Code mgmt tool	HEP standard	In use
cvsweb	cvs web viewer	World standard	In use
cvs	File version mgmt	World standard	In use



SAS Organization

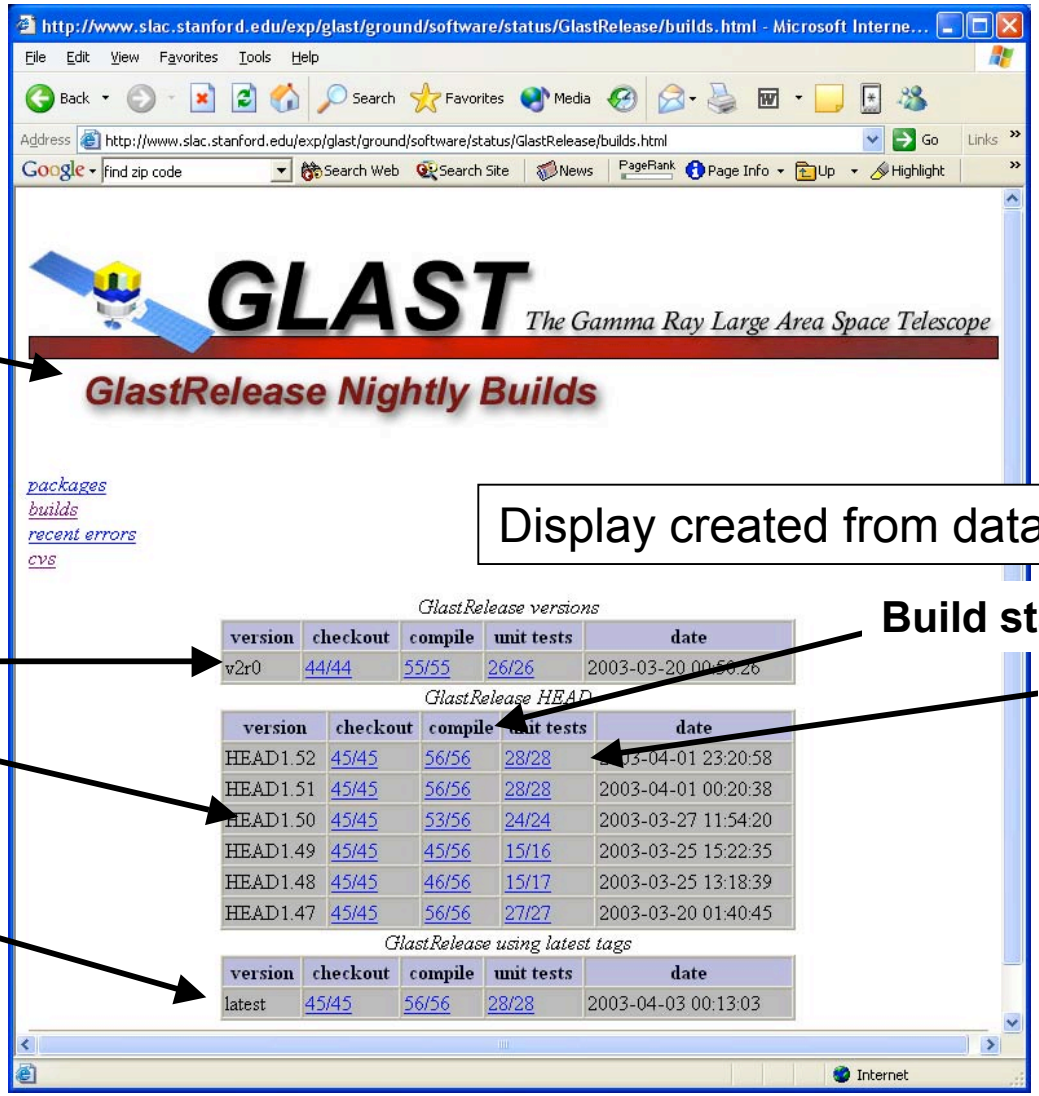


Software Development Approach

- ***Enable distributed development via cvs repository***
- ***Extensive use of electronic communications***
  - *Web conferencing (VRVS), Instant Messaging (icq)*
- ***CMT tool permits equal development on Windows and Linux***
  - *Superior development environment on Windows; compute cycles on linux*
- ***documentation and coding reviews enforce coding rules***
- ***"Continuous integration"***
  - *Eliminate surprises for incoming code releases*
  - *Build code every night; alert owners to failures in build or running of unit tests. Results tracked in database.*
  - *Developing comprehensive system tests in multiple source configurations. Track results in database; web viewable.*

Nightly Builds

Performing builds for Science Tools now also



Display created from database query

Past release

Release in progress

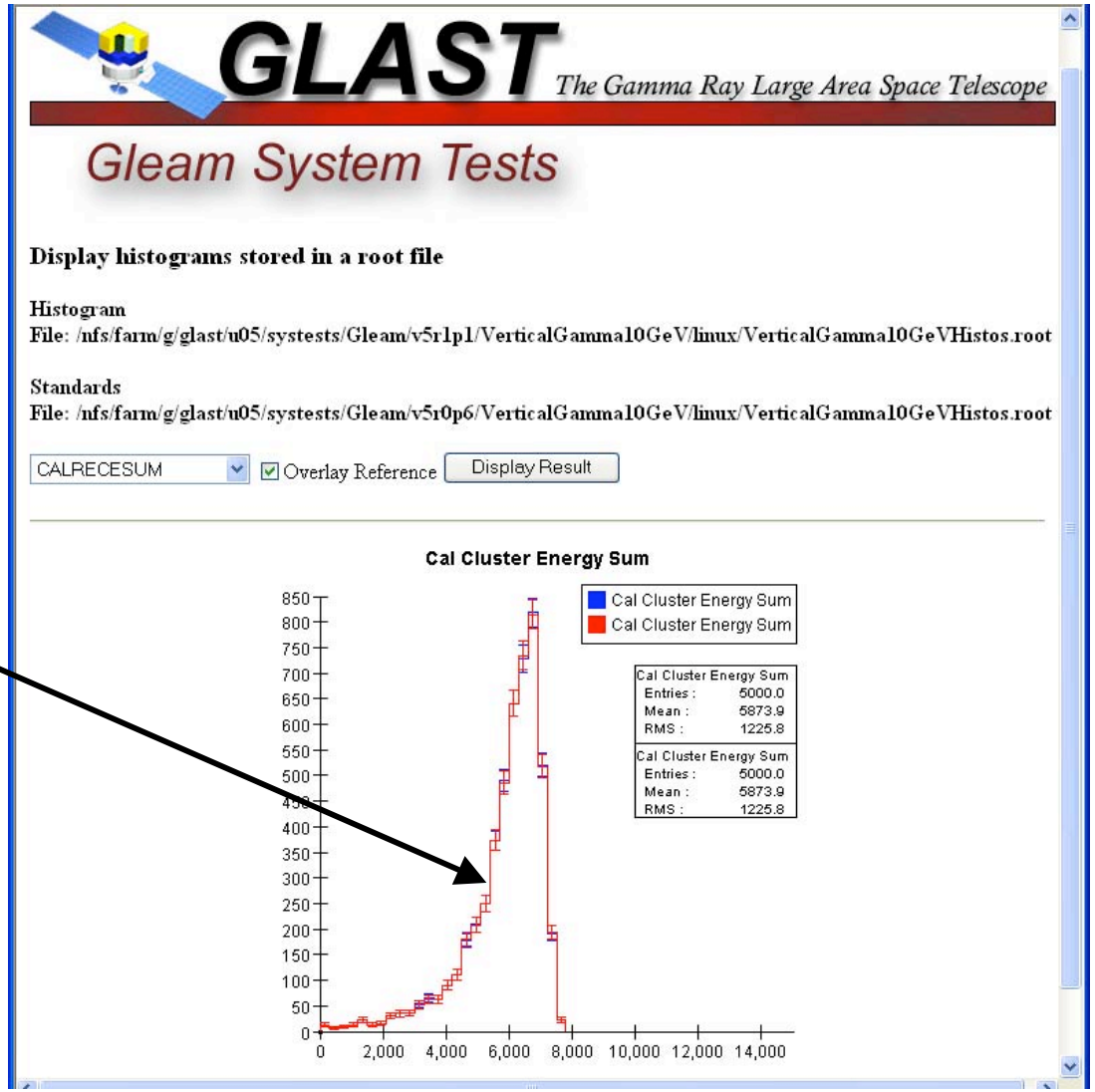
Future release

Build status

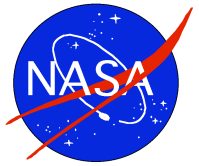
Unit test status

System Tests

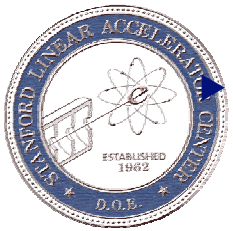
Comparison of current to previous release.



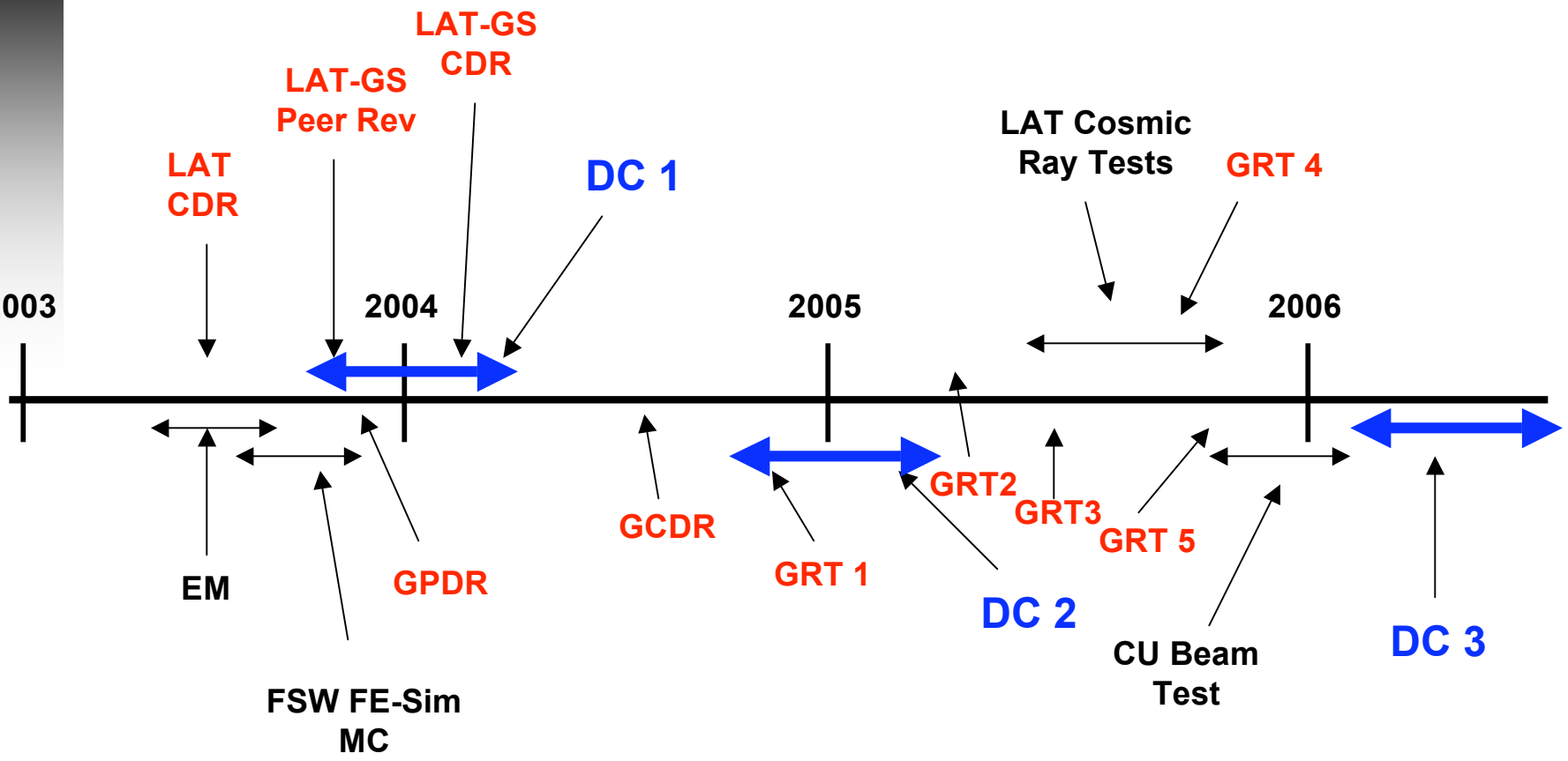
Roadmap to Completion



- ***Use Engineering and Test activities to get an early start on deliverables***
  - *Engineering Model – mid 2003*
  - *LAT Cosmic Rays during integration*
  - *2+ Tower Beam test in late 2005*
  - *Develop tools for use in flight – same tools for all activities*
- ***Use Data Challenges to exercise full LIOC/SAS Ground System***
  - *Simulated instrument data starting from model of sky – same format as flight*
  - *Exercise every component from pipeline through end data analysis*
  - *Schedule ever more demanding Challenges as launch approaches*
- ***Participate in GRT's and End-to-End Tests***



SAS Timeline



Sim/recon, Proto pipeline

Beta SciTools

Release 1

Sim/recon, Proto SciTools, Pipeline, Data xfer to GSSC

Release 2

CU-Validated Sim/recon, SciTools, Final pipeline, Data xfer to SSC

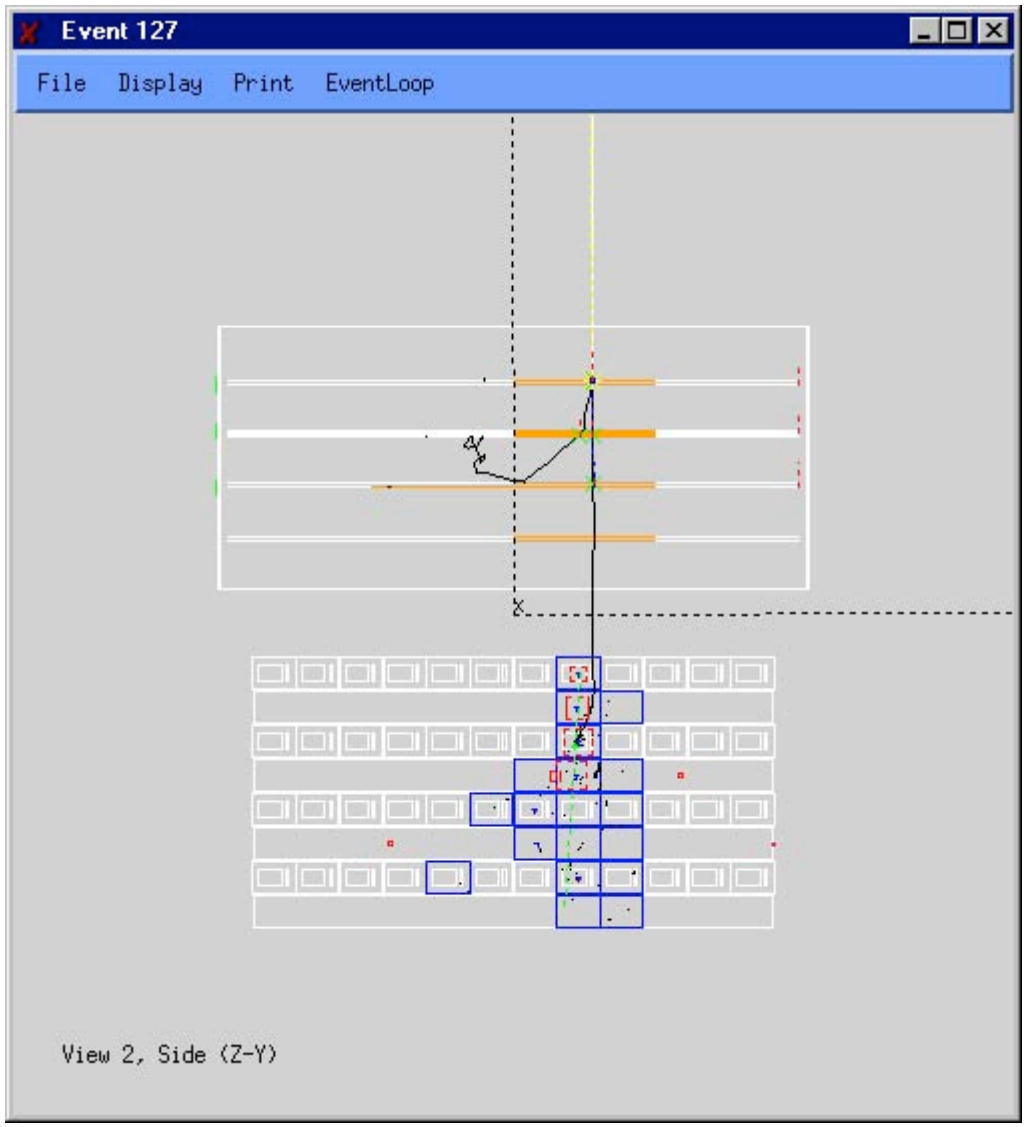
Release 3

Engineering Tests Support – EM – mid 2003

- ***EM Test***
  - *Single tower test unit – mini TKR + CAL*
  - *Cosmic rays and 17 MeV gammas from Van de Graff*
- ***References***
  - *LAT-MD-00446 – SVAC Plan*
  - *LAT-MD-01587 - SVAC EM Tests spec, section 6.1*
  - *LAT-MD-00570 – I&T – SAS ICD for EM*
  - *LAT-TD-01340 – SAS Calibration Infrastructure*
  - *LAT-TD-01588 – Calibration Algorithms for EM*
  - *LAT-TD-00582 – EM Geometry for Simulations*
- ***Required deliverables***
  - *TKR, CAL subsystem calibration algorithms* — **Complete**
  - *Calibration infrastructure for time dependent parameters* — **Complete**
  - *Flexible geometry facility to describe EM unit* — **Complete**
  - *Reasonable fidelity simulation/reconstruction* — **Complete**
  - *Disk & CPU resources for simulation and analysis* — **Complete**

Ready for EM

EM - 18 MeV on-axis photon (from VDG)



Engineering Model
Mini-Tower
(5 trays of material,
3 pairs of active
silicon)

FSW MC Support for FE-Sim – late 2003

- ***Front End Simulator***
  - *Emulates electronic input to digital electronics*
  - *Uses Monte Carlo simulation for realistic patterns*
- ***FSW has requested a full orbit's worth of background to test the Front End Simulator***
  - *~50 Million events*
  - *~1200 CPU-days @ 2 secs per event*
  - *~500 GB output*
- ***Needed around Aug 2003 – resources in place*** **Complete**
- ***MC/Sim already in place*** **Complete**
- ***Must interface FSW code to output flight format data*** **In test now**

Engineering Tests Support – Beam Test – 2005

- ***Beam test (CU)***
  - *Under revision now with re-planning*
  - *Put 2-3 towers in SLAC particle beams to map out response and calibrate simulations*

- ***See***
  - *LAT-MD-00446 – SVAC Plan*
  - *LAT-MD-01587 - SVAC EM Tests spec, section 6.1*
  - *LAT-MD-00571 – I&T – SAS ICD for CU*
  - *LAT-TD-01589 – Calibration Algorithms for CU*
  - *LAT-TD-00583 – CU Geometry for Simulations*

- ***Required deliverables***
  - *ACD subsystem calibration algorithms*
  - *Flexible geometry facility to describe CU*
  - *Good fidelity simulation/reconstruction*
  - *Disk & CPU resources for simulation and analysis*
  - *Processing Pipeline and Data Catalogue*

In planning – 1 man month

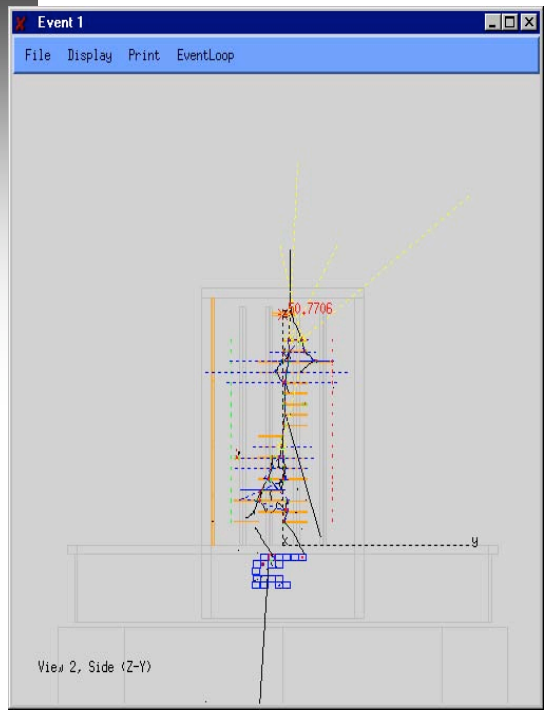
☑ **Complete**

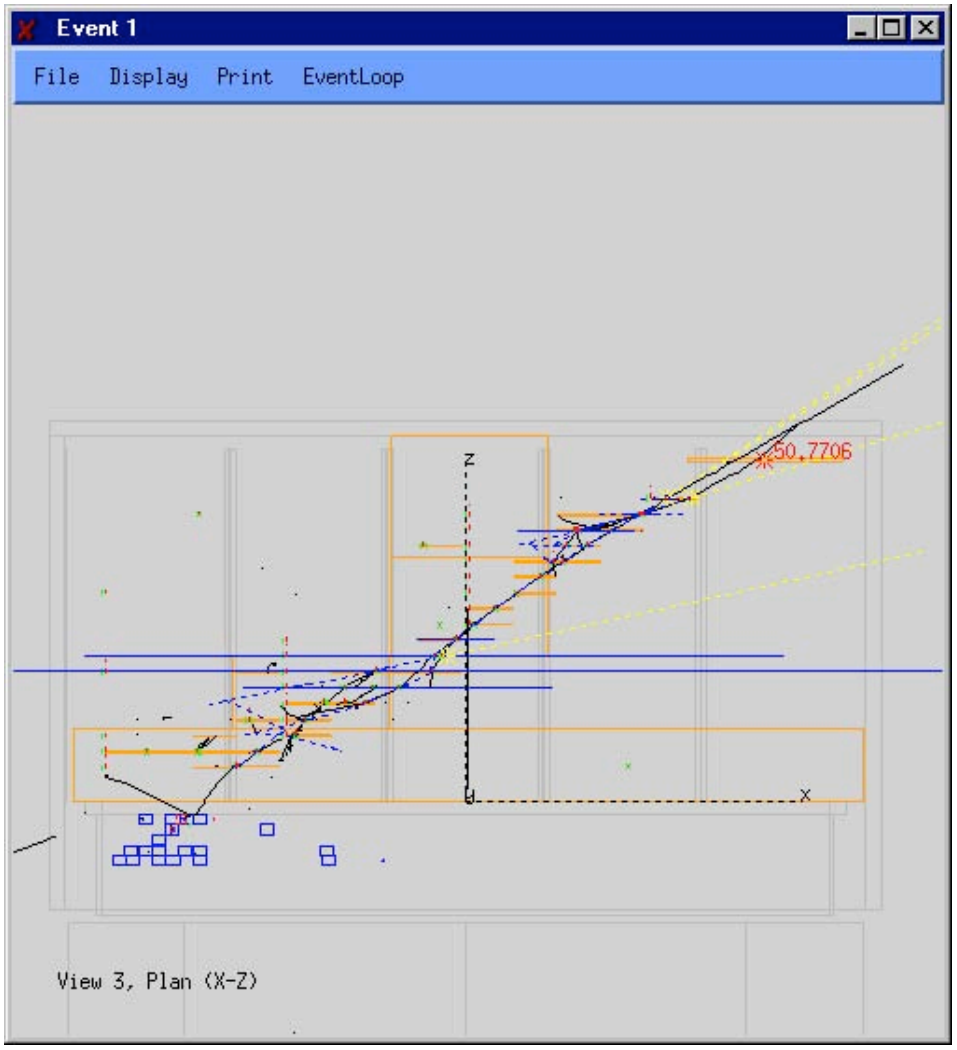
☑ **Complete**

Promised by SLAC

Database complete

CU – 500 MeV angled electron (from test beam)





500 MeV e-

Level 1 Pipeline

- ***Goal is to do early prototyping using EM and MC simulation runs as undemanding clients***
  - *Provide a server that can be configured to run any of the task chains we need*
    - *L1, L2 processing*
    - *MC simulations*
    - *Data reprocessing*
    - *I&T/IOC tasks*
  - *Underlying database design complete*

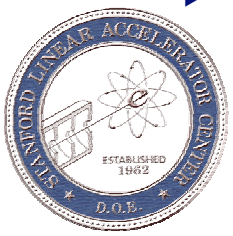
Docs:

database: LAT-TD-00553
server: LAT-TD-00773
diagnostics: LAT-TD-00876

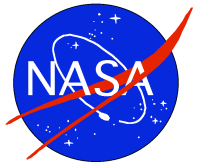
Functional Reqs in draft now

Adapting STScI/Hubble OPUS pipeline Heritage from SLD experiment at SLAC

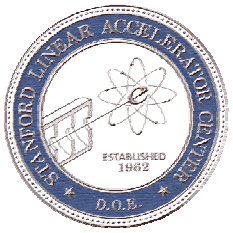
- ***Design interfaces to make the pipeline portable***
  - *Generic database usage*
  - *Interfaces to submit processes to do the work*
- ***First version ready by DC1 if OPUS works out***
  - *In use by Hubble, FUSE, Integral, Chandra, BeppoSax, and SIRTF*
  - *1 FTE-year budgeted to write from scratch if not – ready for CU*



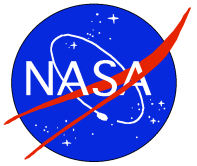
Working with Mission Ground Systems



- ***Contact via biweekly GOWG meetings***
- ***Support Ground System Reviews (GSRR, GPDR, GPDR)***
- ***Support series of Ground Readiness Tests (GRT's)***
  - ***GRT1 (11/04)***
    - ***First transmission of Level 0 data from MOC to IOCs***
  - ***GRT2 (4/05)***
    - ***Initial planning and commanding***
  - ***GRT3 (6/05)***
    - ***Burst Alert processing***
  - ***GRT4 (9/05)***
    - ***Required Level 1 processing with transfer of results to GSSC***
    - ***Will have been done in CU and DC1***
  - ***GRT5 (11/05)***
    - ***More complex planning & scheduling***
    - ***Instrument memory loads (tables and FSW)***



Development of Science Tools

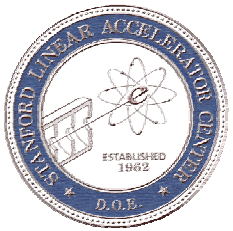


- ***Extensive planning on which tools are needed to do science - and their requirements***
  - *One set of tools for all – "astronomy standard"*
  - *Had external review (9/2002) to see if we are on the right track*
    - *No major problems noted*

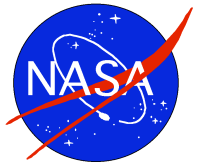
http://www-glast.slac.stanford.edu/ScienceTools/reviews/sept02/report/review_091602.pdf

- ***In progress with the GSSC***
  - *Joint oversight group*
  - *Sorted out technical basis (HEASARC standards; support of community; re-use of LAT developments)*

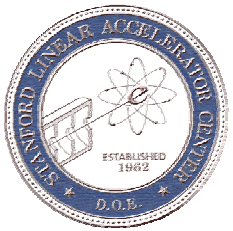
- ***Effort ramping up now***
- ***Selected Level 1 database technology***
  - *Meets performance requirements*
  - *Starting to implement at GSFC*



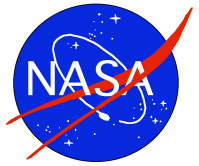
Main Science Tools



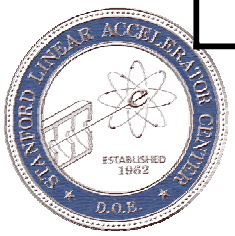
Package	Description
Likelihood	Workhorse model fitting for detection & characterization of cosmic gamma-ray sources
Level 1 database access	Extracts desired event data
Exposure calculation	Uses IRFs, pointing, livetime etc. for deriving calibrated source fluxes
Source identification	Identifies gamma-ray sources with cataloged counterparts at other wavelengths
GRB analysis	Temporal and spectral analyses of burst profiles
Pulsar analysis	Phase folding & period searching of gamma-ray pulsars and candidates
Observation simulator	High level simulation of observations of the gamma-ray sky with the LAT



Science Tools Toolkit

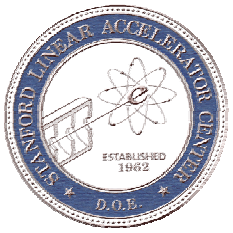


Package	Description	Provider	Status
PIL, PIL++	IRAF parameter access	HEASARC	In use
cfitsio, CCFits	FITS file manipulation	HEASARC	In use
XSPEC, Sherpa	For GRB spectral modeling	HEA standards	Under consideration
Root	gui etc	HEP standard	Under consideration
python	Scripting	World standard	Under consideration
doxygen	Code doc tool	World standard	In use
Visual C++/gnu	Development envs	World standards	In use
CMT	Code mgmt tool	HEP standard	In use
cvsweb	Cvs web viewer	World standard	In use
cvs	File version mgmt	World standard	In use

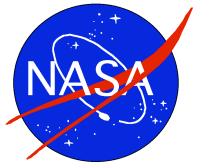


Data Challenges

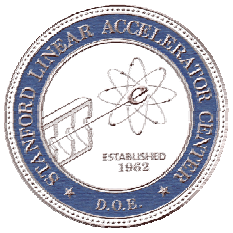
- ***Now traditional in HEP experiments***
  - *exercise the full analysis chain prior to needing it*
  - *involve the collaboration in science prep early*
- ***Doing planning now***
  - *Fall 2003 - DC1*
    - *1 day's data through full instrument simulation and first look at Science Tools*
  - *Fall 2004 – DC2*
    - *1 month's background/1 year signal*
    - *Test more Science Tools; improved Pipeline*
  - *Spring 2006 – DC3*
    - *run up to flight – test it all!*
  - *DC1 Plans*
    - *Focus effort through Analysis Group (S.Ritz) and workshop held in mid-July*
    - *Sept collaboration meeting as milestone for start*



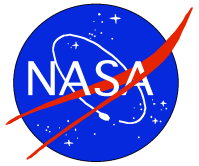
Prep for IOC Peer Review and CDR



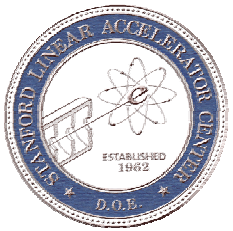
- ***SAS was baselined in LAT PDR – 01/2002***
- ***LAT IOC Ground Systems CDR has been scheduled for 2/2004, with Peer Review in 11/2003***
- ***Expectations for Peer Review***
  - *Successful EM support*
  - *Level 1 Prototype operational*
    - *Functional requirements; Design documents ready*
  - *Science Tools*
    - *Major components understood, with schedule, manpower and milestones*
    - *Plan to schedule next external review to be coincident with Peer Review*
  - *ICD with GSSC*



Summary



- ***SAS driven by Engineering Tests and LAT Integration***
  - *EM support ready; CU looking good*
  - *Sim/Recon in place*
- ***Science Tools under development***
  - *In concert with the SSC*
  - *Drive schedule with Data Challenges*
- ***Level 1 Pipeline early start***
  - *Trying to have prototype in place for FSW & DC1 support this year*
  - *End-to-end tests scheduled with Mission Ground Systems*



Internal validation, Beam tests and Data Challenges in place to ensure successful Ground Readiness well before launch.